MS
MIN-ESN

HLR
*MIN-ESN
home service provider information
subscriber information
  mobile station priority
  PACA level
  preferred language
terminal information
cellular subscriber name
street address •
Lat-Long-Alt-Resolution •

U_m

BS/BSC
pANI7=sector
Lat-Long-Res •
street addr •

D

VLR

A   B

Cell Information Database
*cell identification
cell location information
pANI

X_f

MSC
TLDN
serving service
provider information

X_a and X_c may be A_i or D_i

X_a ANI, pANI •
Lat. Long.

*Latitude-Longitude •
street address
primary PSAP
alternate PSAPs

X_m•

Selective Router

X_c X_b X_h

X_d

Selective Router Database
*ANI7/pANI7
primary PSAP
secondary PSAPs

PSAP

X_n •

Secondary PSAP

X_i X_i

ALI
*ANI7 /pANI
land line subscriber street address
land line subscriber name

cellular subscriber location (sector)

MIN   Mobile Identification Number
ESN   Electronic Serial Number
ALI   Automatic Location Information
PSAP   Public Safety Answering Point
MS   Mobile Station
BS   Base Station
BSC   Base Station Controller
VLR   Visitor Location Register
MSC   Mobile Switching Center
TLDN   Temporary Local Directory Number
HLR   Home Location Register
PACA   Priority Access and Channel Assignment
MDN   Mobile Directory Number
pANI   Pseudo Automatic Number Identification
pANI7   7-digit (or 8-digit) pseudo ANI
ANI7   7-digit (or 8-digit) ANI
*   database key
•   change from the previous figure

Figure 10: Evolutionary Path C Information Element Sources

Figure 11: Evolutionary Path D Information Element Sources

MIN   Mobile Identification Number
ESN   Electronic Serial Number
ALI   Automatic Location Information
PSAP   Public Safety Answering Point
MS   Mobile Station
BS   Base Station
BSC   Base Station Controller
VLR   Visitor Location Register
MSC   Mobile Switching Center
TLDN   Temporary Local Directory Number
HLR   Home Location Register
PACA   Priority Access and Channel Assignment
MDN   Mobile Directory Number
pANI   Pseudo Automatic Number Identification
pANI7   7-digit (or 8-digit) pseudo ANI
ANI7   7-digit (or 8-digit) ANI
*   database key
•   change from the previous figure

9. Location Technologies

A number of wireless caller location technologies were presented. The technologies are available or are proposed and have different capabilities. Approaches ranged from equipment placed at the cell site (requiring little or no change to the mobile station) to autonomous position determination equipment placed in the mobile station. Contribution WJEM(911)/94.10.11-011 (a report commissioned by APCO and the State of California) contained synopses of methods and products to determine position.

9.1 Minimum Location Requirements

Establishment of definitive minimum requirements at this time may be premature. However, there are certain generic requirements that can be postulated.

9.1.1 Time Requirements

Location information is used to support two parts of the delivery of the 9-1-1 call to the Emergency Response System:

- Routing a 9-1-1 call to an appropriate PSAP

- Facilitating the emergency service response itself

The time requirements associated with the above may in fact differ:

- Caller location information sufficient for routing a 9-1-1 call to an appropriate PSAP should be available within, and not delay, the normal call processing interval.

- More accurate caller location information designed to facilitate emergency response should be displayed at a PSAP call taking station no later than 5 seconds from the time the PSAP receives the call.

The realization of these requirements is contingent on technical and economic feasibility.

9.1.2 Minimum Requirements

- In the event that time does not allow the use of the most accurate location information possible for routing a 9-1-1 call, the best available location information to support such routing should be provided.

- The best available location information may be different for different systems, as well as for "home" and "roaming" subscribers.

- The public safety community's desire is for caller location information to be as accurate and precise as possible.

1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
23
24
25
26
27
28
29
30
31
32
33
34
35
36
37
38
39
40
41
42
43
44
45
46
47
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63

- • Actual 9-1-1 location information requirements as they pertain to home and roaming subscribers are ultimately implementation issues, subject to local agreements between the service provider and the public safety community.

10. Contributions

The following documents were contributed to the Joint Experts Meeting:

Number	Title	Author
WJEM(911)/94.10.11-001	A Proposed In-Band Message Protocol Set	David Kelley - Terrapin Corp.
WJEM(911)/94.10.11-002	AT&T Public Safety Systems 911 Data Network Solution	Larry Ciesla, Mike Meyer and Carolyn Robins - AT&T
WJEM(911)/94.10.11-003	AT&T Public Safety Systems Common Channel Signaling Network Solution	Larry Ciesla, Mike Meyer and Carolyn Robins - AT&T
WJEM(911)/94.10.11-004	DF Localization for E-911	Charles Hinkle - KSI Inc.
WJEM(911)/94.10.11-005	On-Going Cellular Geolocation Based IVHS Operational Test	Joe Kennedy - Engineering Research Associates
WJEM(911)/94.10.11-006	Call-Before-You-Dig	James Weigant - OneCall Systems
WJEM(911)/94.10.11-007	Emergency Access Position Paper	PCIA, APCO, NASNA
WJEM(911)/94.10.11-008 (same as 033)	TIA TR45 JEM Report on Emergency Services	TIA TR45
WJEM(911)/94.10.11-009	9-1-1...New Jersey's Lifeline	S. Robert Miller - State of NJ
WJEM(911)/94.10.11-010	Priority Cellular Access Service	Randy Schulz - Bellcore
WJEM(911)/94.10.11-011	Survey of Location Technologies to Support Mobile 911	C.J. Driscoll & Associates
WJEM(911)/94.10.11-012 WJEM(911)/94.10.11-013 WJEM(911)/94.10.11-014	Data Considerations for Enhanced 911 Display of Wireless Device Locations	John Melcher - Greater Harris County 911 and Beth Ozanich - Tarrant County 911 District
WJEM(911)/94.10.11-015	User Location Information	Thera Bradshaw, NENA Steve Proctor, UITS Mary Boyd, NASNA
WJEM(911)/94.10.11-016	PSAP Service Requirements	Thera Bradshaw, NENA Steve Proctor, UITS Mary Boyd, NASNA
WJEM(911)/94.10.11-017	E911 CPE Perspective on the Installed Base	Ian McGraw, Plant Equipment, Inc.
WJEM(911)/94.10.11-018	An Approach to Locating Wireless Transmitters for Public Safety	Lou Stilp, Associated Communications Corp.
WJEM(911)/94.10.11-019	Radio Location Technology Evaluation Guidelines	Robert Voss, MCI
WJEM(911)/94.10.11-020	NENA Recommended Formats for Data Exchange	Thomas Hicks, NENA
WJEM(911)/94.10.11-021	NENA Recommended Protocols for Data Exchange	Thomas Hicks, NENA
WJEM(911)/94.10.11-022	NENA Recommended Standard for Street Thoroughfare Abbreviations	Thomas Hicks, NENA
WJEM(911)/94.10.11-023	Wireless Enhanced 911	Mike Lucy, Smith Advanced Technology, Inc. Michael Rendak, Rockwell International Corp.
WJEM(911)/94.10.11-024	911 Tutorial 911 Technology	Joe Blaschka, Adcomm Engineering, Co.
WJEM(911)/94.10.11-025	Effects of Wireless Communications & Advanced Technology on Enhanced 911 Systems	Joe Blaschka, Adcomm Engineering, Co.

Number	Title	Author
WJEM(911)/94.10.11-026	SS7 Data Elements	Joe Blaschka, Adcomm Engineering, Co.
WJEM(911)/94.10.11-027	U.S. Interagency Committee on Search and Rescue (ICSAR) Activities on Use of Mobile Satellite Systems in Search and Rescue (SAR)	Glenn Roach, St. of Mass. 911
WJEM(911)/94.10.11-028	T1P1 & TR46 Network Reference Models	PCIA
WJEM(911)/94.10.11-029	Ground Rules	Gary Jones, JEM Co-Chair
WJEM(911)/94.10.11-030	Proposed Agenda	Gary Jones, JEM Co-Chair
WJEM(911)/94.10.11-031	JEM Schedule	Gary Jones, JEM Co-Chair
WJEM(911)/94.10.11-032	FCC News Release on Action on 911	FCC
WJEM(911)/94.10.11-033	TIA TR45 JEM Report on Emergency Services (same as 008)	Terry Jacobson, AT&T
WJEM(911)/94.10.11-034	Public Safety Answering Point Automatic Location Identification Requirements	Michael Celeski, Pertech America, Inc.
WJEM(911)/94.10.11-035	Overview of a Proposed E911 Wireless Network Architecture Migration Path	US West Communications, Inc. Public Safety Group
WJEM(911)/94.10.11-036	Overview of A Typical E911 Network Architecture	US West Communications, Inc. Public Safety Group
WJEM(911)/94.10.11-037	Wireless Location Overview & Path Forward	F. Warren LeBlanc, US West Technologies, Inc.
WJEM(911)/94.10.11-038	Tutorial on 911 Emergency Services	Mary Boyd, Texas Commission on State Emergency Communications
WJEM(911)/94.10.11-039	JEM Document Assignment	Gary Jones, JEM Co-Chair

11. Participants

Name	Organization	Phone	FAX
Brian Daly	AG Communication Systems	602-582-7503	602-582-7111
Marty Wiehshienk	AG Communication Systems	602-582-7503	602-582-7111
Brent Andrew	AirTouch Communications	415-658-2062	415-658-2283
Huel Halliburton	AirTouch Communications	510-210-3666	510-210-3578
Rick Judson	AirTouch Communications	510-210-2954	510-210-3578
Frank Panek	Ameritech	708-248-6061	708-248-6013
Ed Gilbert	AMSC	703-241-2592	703-241-2592
Rocco LaPenta	American Personal Communications	202-785-9545	202-822-9615
Steve Zweifach	American Personal Communications	202-785-9553	202-835-8326
Joe Blaschka	Adcomm Engineering Company	206-821-8827	206-488-3952
Ben Levitan	ARINC	410-266-4111	410-266-2047
Martin Thompson	Artel	703-620-1700	703-620-4262
Jeff Krauss	Associated Communications Corp.	301-309-3703	301-309-9323
Louis Stilp	Associated Communications Corp.	610-660-4910	610-660-4920
Sandy Abramson	AT&T	908-957-4496	908-954-4099
Larry Ciesla	AT&T	708-224-6747	708-224-4524
D. Furman	AT&T	908-221-6036	908-221-8198
Frank LaPorta	AT&T	908-234-4668	908-234-8681
Mike Meyer	AT&T	708-224-7382	708-224-4524
Terry Jacobson	AT&T Bell Labs	708-713-1665	708-713-1468
A.G. Caggiouic	AT&T Corp.	908-771-3890	908-771-4503
Bob Gojanovich	Bell Atlantic	609-599-8222	609-771-6022
Walt Kraeft	Bell Atlantic	201-649-8284	201-481-6547
Matt Lewis	Bell Atlantic	301-236-2480	301-236-8598
Wendall McClellan	Bell Atlantic	301-236-2484	301-236-8598
Tom Offutt	Bell Atlantic	410-393-4614	410-393-3629
Steve Carlson	Bell Northern Research	919-991-7352	919-991-8073
L. Gopal Iyengar	Bell Northern Research	919-991-7205	919-992-0223
Pete Campanella	Bellcore	908-758-2346	908-758-4191
Don Grise	Bellcore	201-740-4130	201-740-6929
P.J. Louis	Bellcore	201-740-4595	201-740-6929
Ron Steen	BellSouth	205-977-7268	205-977-7222
Linda Tate	BellSouth	205-977-2351	205-977-2287
Don Zelmer	BellSouth	404-249-6791	404-249-4489
Stephen Blust	Bellsouth-Wireless	404-249-5058	404-249-5157
Linda Lancaster	BellSouth Wireless	404-249-6710	404-249-5347
Bill Mayberry	BellSouth Wireless	404-249-0609	404-249-5126
Bill Buchholtz	Bexar Metro	210-366-3911	210-366-0050
Mike Hammer	Booz Allen & Hamilton Inc.	703-902-5477	703-902-3354
Clem Driscoll	C.J. Driscoll & Associates	310-832-8834	310-832-3468
Bernie Trudell	Computer Sciences Corporation	301-927-6608	301-927-2948
Ed Hall	CTIA	202-736-3259	202-785-0721
Brian Choi	DISA / JIEO	703-696-1907	703-696-1929
Robert Mather	DOJ/CRD	202-301-2236	202-301-0595
Joe Kennedy	Engineering Research Associates	703-827-9438	703-827-9410

Name	Organization	Phone	FAX
Nils Bojeryd	Ericsson	214-997-3063	214-907-7967
Ben Ewart	Ericsson Radio Systems	214-952-8743	214-952-8785
Ed Gilbert	Gilbert & Associates	703-241-2592	703-241-2592
John Melcher	Greater Harris County 9-1-1 Emergency Network	713-863-9911	713-864-9911
Philip Celli	GTE Information Services	813-273-4702	
Jeff Crollick	GTE Telecommunication Services	813-273-4776	813-273-4977
Anthony Simpson	GTE Telecommunication Services	813-273-4713	813-273-4801
Russ Russell	GTE Telephone Operations	214-718-7911	214-718-5275
Chuck Hinkle	KSI Inc.	703-941-5749	703-941-5786
John Maloney	KSI Inc.	703-941-5749	703-941-5786
Glenn Roach	Commonwealth of Massachusetts Statewide Emergency Telecommunications Board	617-272-1911	617-272-5101
Ross Baker	McCaw Cellular	206-389-5301	206-389-5382
Jane Bissonnette	McCaw Cellular	206-828-8005	206-828-8085
John Draim	Mobile Communications Holdings	202-466-4488	202-466-4493
Bob Voss	MCI	214-498-1152	214-498-1147
Herb Calhoun	Motorola	817-232-6262	817-232-6580
Lou Linneweh	Motorola	708-632-5044	708-632-3145
An Nguyen	NCS	703-692-7857	703-746-4960
Stephen Jones	NEC	214-518-5016	214-518-5160
Thomas Hicks	NENA / GTE Telephone Operations	214-718-4289	214-718-7796
Richard Lamerdin	Nextel	510-299-3416	510-299-2373
Teuvo Jarvela	Nokia	817-355-9819	817-355-9881
Rick Hessinger	North Dakota Radio Communications Department	701-224-2129	701-224-2126
David Gorzocoski	Northern Telecom	214-684-5473	214-684-3905
Bob Hight	Northern Telecom	919-992-8029	919-992-0223
Donald Keelep	Nothern Telecom	214-684-5680	214-684-3805
Yiuman Leurg	Northern Telecom	214-684-1004	214-684-3744
Bruce Seawood	Northern Telecom	615-734-4926	
Eldon Haakinson	NTIA / ITS	303-497-5304	303-497-3680
E.P. Hoyt	Omnipoint	719-548-1200	719-548-1393
Gary Jones	Omnipoint	719-548-1200	214-713-5397
James Weigant	OneCall Systems	412-323-7148	412-323-7148
Wayne Hembree	Orbital Communications	703-406-5307	703-406-3504
Ken Keim	Oregon St. Police	503-378-2911	503-588-1378
Eileen Healy	Pacific Bell Mobile Services	510-227-3075	510-227-3079
Matthew Burkett	Personal Communications Industry Association	202-467-4770	202-467-6987
Mary Madigan	Personal Communications Industry Association	202-467-4770	202-467-6987
Ian McGraw	Plant Equipment	909-676-9802	909-676-9651
Valerie Shuman	SEI Technology Group	708-699-6500	708-699-6553
Mike Lucy	Smith Advanced Technology	205-533-3822	205-534-7461
Richard Atkins	Southwestern Bell	214-464-3911	214-464-4294
Rolyn Callahan	Southwestern Bell	314-529-7424	314-529-7674
John Camp	Southwestern Bell	214-464-4863	214-464-4623
David Kelley	Terrapin Corp.	714-898-8200	714-895-7526
Jeffrey Krauss	Telecommunications and Technology Policy	301-309-3703	301-309-9323
Eric Schimmel	Telecommunications Industry Association	202-457-4990	202-457-4939

Name	Organization	Phone	FAX
Mary Boyd	Texas Advisory Commission on State Emergency Communications	512-305-6911	512-305-6937
Jim Goerke	Texas Advisory Commission on State Emergency Communications	512-305-6920	512-305-6937
Chris Wilson	TRW	408-743-6068	
Gerry Coe	US West Communications	303-896-8308	303-965-1059
Donnie Griffin	US West Communications	206-345-1402	206-346-9435
Ken White	US West Communications	303-965-0068	303-898-1237
Warren LeBlanc	US West Advanced Techologies	303-541-6125	303-541-6384
Stuart Jeffery	VisiCom Laboratories	415-966-8199	415-966-8456
Colin Hirayama	VisiCom Laboratories	214-340-0703	214-340-6108
Charles Larkin	Vermont Department of Public Service	802-828-4008	802-828-2342
Robert Gurss	Wilkes, Artis, Hedrick & Lane	202-457-7329	202-457-7814

12. Recommendations

Forward the JEM Report to the TIA, Committee T1 and NENA for study and the development of standards for:

- The interfaces and wireless system operations described

- Mobile station enhancements described

- Air interface issues raised

Forward the JEM Report to the FCC, APCO, PCIA, Cellular Telecommunications Industry Association (CTIA), NASNA, North American Numbering Plan Administrator (NANPA), and other interested organizations for their consideration.

Annex A - ALI Information Requirements

This annex applies to evolutionary path A and specifies requirements for the transfer of call related information between the wireless system and the emergency service system in a non-real time mode.

A. Calling Party Number

- ANI

B. Calling Party Address

- For Home System subscribers, this field may contain the subscriber's billing address (at the option of the PSAP).

C. Customer Name

- For Home System subscribers, this field may contain the name of the subscriber.

D. Class of Service

- Mobile = 8

E. Type of Service

- Published = 0

- Non-published = 3

F. Exchange

- Text that indicates type of Wireless Service Provider

  — "Cell" = Cellular

  — "PCS" = Personal Communications Service/Network

  — "MSS" = Mobile Satellite System

G. Emergency Service Number

- Assigned by the PSAP

H. Main NPA and Number

- Directory number of the serving Wireless Service Provider

I. Company ID

- Assigned as required

J.   Comments

- PSAP defined remarks.

Annex B - Position Location Capability

This section is included for information purposes only and is not an attempt to endorse any particular technology.

B.1 Introduction

This section gives a brief description of technologies, either existing or proposed, that may provide the information necessary for emergency service providers to locate a 9-1-1 caller who is using a mobile station.

While this JEM report is focused on CMRS, it is important to note that another major effort is underway in the U.S. The Department of Transportation, which has initiated its Intelligent Vehicle Highway System (IVHS) program, relies heavily upon untethered communications and location information to deliver a major portion of its anticipated benefits. Synergy between CMRS and IVHS is expected to produce cost effective solutions for the public safety community.

B.2 Location Technologies

Although every attempt has been made to include, at least from a generic standpoint, existing or emerging technologies, some may have been inadvertently omitted. Time and interest will likely attract other entrants into the process.

As the following figure shows, location technologies can be generically categorized.

Annex B

Figure B.1   Location Technology Categories
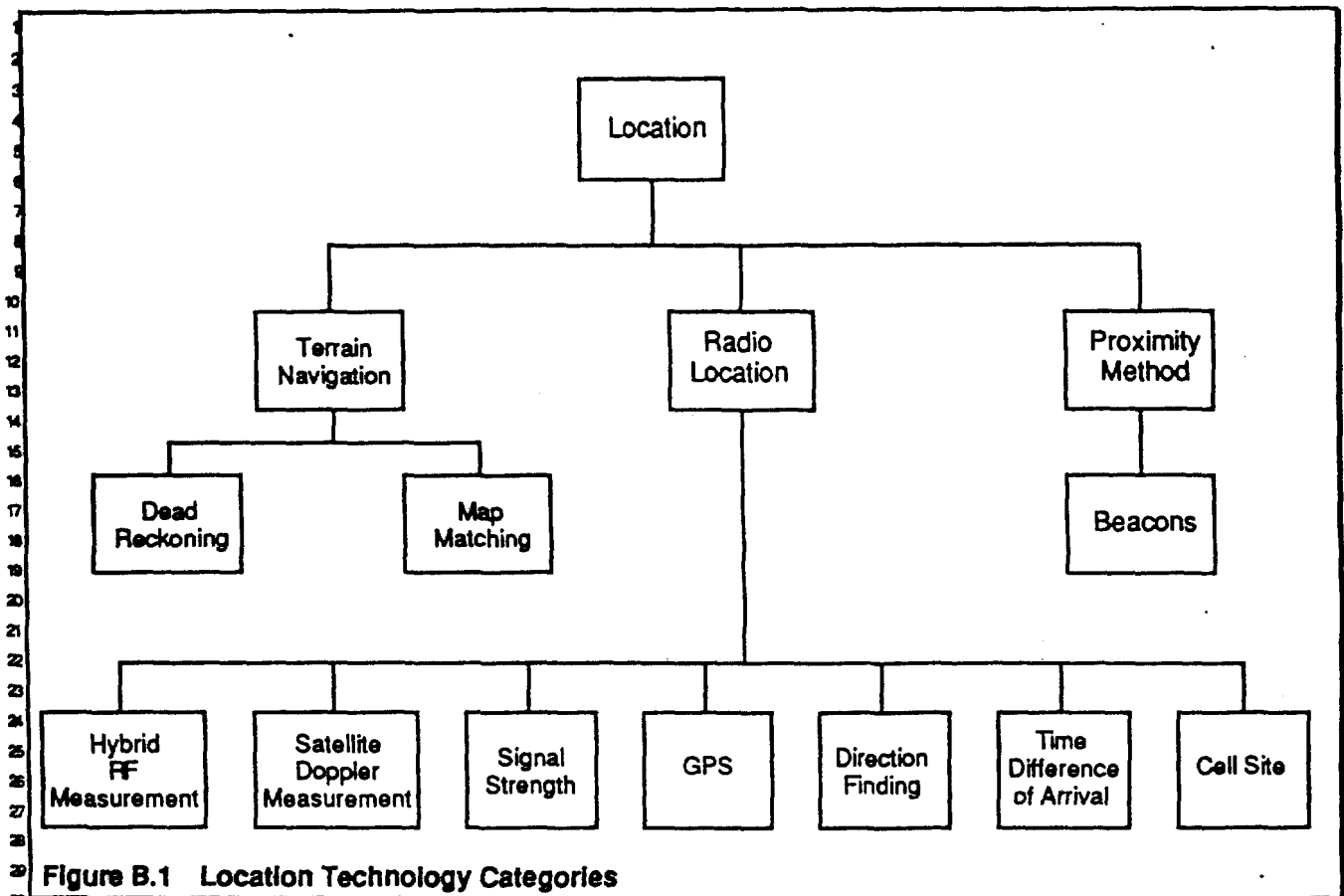
Techniques for providing position/location can be described in the following generic terms:

- Direction Finding (DF)

- Time Difference of Arrival systems (TDOA)

- Global Positioning Systems (GPS)

- Terrain navigation - dead reckoning and map matching

- Hybrid measurement techniques

- Satellite Doppler measurement systems

- Loran-C

- Other land-based radiolocation systems

B.2.1 Direction Finding

Direction Finding (DF) systems, also referred to as Direction-of-Arrival (DOA) or Angle-of-Arrival (AOA) systems, detect radio frequency (RF) emissions using phased-array antennas and receivers that operate passively in the wireless frequency bands. DF systems process the signals to determine their angles of arrival. Upon detection at two or more antenna sites, the calculated directional information is then passed to a central control location where location is computed. DF is thus used in network-centric system configurations.

B.2.2 Time-Difference-of-Arrival

Time-Difference-of-Arrival systems measure the differences between the arrival times of the signal at different receivers (base stations). The path that would be followed by a TDOA transmitter traveling in a manner that maintains a constant time-of-arrival difference between any pair of base station receivers is a hyperbola. The transmitter (e.g. mobile station) is located at the point of intersection of two hyperbolas based on time of arrival difference measurements at three base stations. TDOA is used in network centric systems to compute caller location using signals transmitted from a wireless phone.

B.2.3 Global Positioning System (GPS)

GPS is available for public use. To provide the location information at an external site, a communication capability in the mobile system is used. The satellite signals can be blocked by buildings or foliage.

Satellite systems other than GPS which provide for communications and radio determination, typically rely on signals transmitted to or from three or more satellites (or two satellites and a fixed ground station) to a receiver.

B.2.4 Other Land-Based Radiolocation Systems

Other land-based radiolocation systems have been developed which use signals from existing non-telephony networks (e.g., FM) or private base stations to compute location using triangulation, TDOA or other techniques. In addition, Automatic Vehicle Monitoring (AVM) systems have been deployed in a number of U.S. cities which compute location by measuring time difference of arrival of signals transmitted from in-vehicle transponders to multiple network base stations. Data from base stations is transmitted to a control center, where location is computed.

B.2.5 Hybrid Measurement Techniques

Hybrid measurement techniques can be supersets or subsets of other described techniques or may employ RF measurement techniques, which rely on the wireless communications channels between the mobiles and base stations or radio ports. Examples of measurements include signal strength, word or bit error rate and signal-to-noise ratios. Measurements may be taken in both uplink and downlink directions. Data reduction methods may be performed on data collected from the RF measurements in order to determine a correlation with location.

B.2.6 Terrain Navigation

Terrain navigation systems use what is called "dead reckoning" (DR) or "map matching". In a DR system, calculations are made on distance and direction traveled relative to where the vehicle started or was last calibrated. These systems use sensors on the vehicle to measure parameters such as tire rotation for distance and compass orientation for direction. These systems can transmit coordinate data to a user base station, through a communication device installed in the vehicle. To maintain accuracy, these systems require periodic calibration through integration with another system such as a map matching and/or a satellite positioning system.

Map matching systems use DR techniques, but also include processing of the sensor information in concert with a data base containing the area road and street structure. The calculated locations can be continuously adjusted to conform to the nearest "known" street. When significant changes in direction are detected, they are matched to the most likely feature represented in the map data which is used to adjust the assumed vehicle location. This approach assumes that processing and database facilities are installed at a site external to the vehicle, and that the vehicle communicates with that site.

B.2.7 Satellite Doppler Measurement Systems

The high velocity of low earth orbiting satellites relative to a mobile station, causes an apparent shift in transmitted radio frequency known as Doppler shift. Techniques exist for using the Doppler shift to locate the mobile station.

B.2.8 Loran-C

Loran-C is a low frequency (90-110 kHz) transmitter network. For position determination, a Loran receiver in a vehicle receives the reference signals and determines the vehicle's latitude and longitude. As needed, location information is transmitted from the vehicle to a site external to the vehicle through a communications device. The accuracy on land is often degraded due to weather conditions and electrical interference. No contributor to the JEM proposed a solution using Loran-C.

B.3 Location Technology Considerations

B.3.1 Multiple Location Technologies Exist

There are multiple location technologies that may be used to determine the location of a wireless device. A list of location technologies submitted to this JEM are included in this Report. Not all the technologies address the multiple RF air interfaces, system architectures, and operating environments which exist (e.g., 800 MHz PCS) or are proposed (e.g., 1800 MHz PCS).

B.3.2 Location Technologies Are Not Mature

Location technologies applicable to CMRS to satisfy the 9-1-1 needs are not mature. Location technologies should be functionally integrated into wireless terminals, base station systems, wireless switching and intelligent network systems, as required, to provide end-to-end solutions.

Performance analysis of the location technologies for various architectures and operating environments will require additional development and testing.

B.3.3 Multiple Architectures Exist

The following architectures may be used for CMRS:

- Megacells - Satellite Based Systems

- Macrocells

- Microcells

- Picocells

- Distributed Antennas:

    — Remote Antenna Driver Systems (RADS), Remote Antenna Signal Processors (RASPS)

    — Coax /Fiber Distribution

- Repeaters/Enhancers/Translators

- Omni/Sectored/Smart antenna configurations

- Three Dimensional Cell Structures

- Hierarchical Cell Structures (multi-layer)

B.3.4 Multiple Physical Environments Are Present

CMRS may operate in the following environments:

- Dense urban (e.g., New York City)

- Urban

- Suburban/rural

- Indoor (from skyscraper to farmhouse)

- Highway

- Outdoor (water, open field, forest, etc.)

- Three dimensional cell structure (e.g., floors in a building)

- Other (subway/enclosed stadium)

B.3.5 Multiple Radio Air Interfaces Must Be Accommodated

For the 800 MHz band the following air interface technologies are already deployed or have been proposed:

- AMPS (EIA/TIA-553, TIA/EIA *IS-91*)

- NAMPS (TIA/EIA *IS-91*)

- TDMA (TIA/EIA *IS-54-B*)

- CDMA (TIA/EIA *IS-95*)

- Extended TDMA (ETDMA)

- Interdigital Corp. Overlay Broadband CDMA

- Motorola MIRS ESMR

- Geotek ESMR

The following are JTC[1] Candidate Technologies for 1800 MHz:

- Up banded *IS-54*

- 1.25/2.5 MHz CDMA

- 5 MHz CDMA

- PCS 1900

- PACS

---

[1] Joint Technical Committee on Wireless Access

- Omnipoint Hybrid TDMA/CDMA

- DCTU

Other air interface technologies, including satellite based systems, are under development and may be deployed.

B.3.6 No Integrated Solutions Evident Today

Efforts to integrate the various location technologies into CMRS by system infrastructure and subscriber equipment vendors are in the formative stages. No contributions were submitted by any CMRS equipment manufacturer (including 800 MHz and 1800 MHz PCS) regarding their current abilities or deployment plans for radio location equipped systems. Only contribution WJEM(911)/94.10.11-009 described an integrated end-to-end test (i.e., prototype) system capable of call routing to a PSAP based upon location.

B.3.7 System Impacts May Be Significant

The adoption of a location technology may impact many network elements of CMRS including mobile stations, base station systems, MSCs, HLRs, VLRs, and intelligent network systems. The magnitude of the impact varies depending on the location technology chosen. No location solution is impact free.

B.3.8 Implementation Is An Evolutionary Process

The merging of location technologies into existing and emerging wireless systems is an evolutionary process that will take time and will probably be implemented in a phased approach.

The following recommendations are made:

- Evaluation of any location technology should be done for the various air interfaces, system architectures and operating environments. This will allow for determination of applicability and performance for each candidate technology.

- Integration into existing and new RF/switching infrastructure is critical. Further investigation into product availability is warranted.

- Conceivably, incompatible location technologies may be deployed in markets with compatible air interfaces, by different license holders. This could result in degraded ability to provide location information for mobile stations that are designed for other licensees' systems. Standards should be required to provide default location information capability.

B.4. Format

The format of information relative to location can be expressed in numerous ways. Sections 5 and 6 of this Report suggest latitude, longitude, altitude, resolution and accuracy. Additional data elements include the source of the location information, the technique utilized to obtain the location, the "timeliness" of the information, and an indication of changing location.

Regardless of the format chosen in a particular implementation, the information shall be structured in a standardized and uniform manner appropriate to the intended use of the information. Consideration should be given to adopting standard navigational notation for position description (e.g., the list of standard terms and definitions currently being developed by the Institute of Navigation).

- Data Structures: whatever format is established, it must not impede the evolution and implementation of new or enhanced location technologies.

- In addition to the data formats identified in NENA's recommendation for data exchange (contribution WJEM(911)/94.10.11-020), it is suggested that information elements include the following:

    — Indication as to source of location information

        a. Name of service provider

        b. Type of location technology

    — Date-time stamp (one second resolution)

    — Geometric location information, for example:

        a. Circle

            1) center latitude (allow to 0.1 meters)
            2) center longitude
            3) center altitude
            4) radius (allow to 1 meter)

        b. Pie segment (sector)

            1) apex latitude
            2) apex longitude
            3) apex altitude
            4) radius
            5) degrees from true north start radial
            6) degrees from true north stop radial

        c. Polygon

            1) center's latitude
            2) center's longitude

> 3) center's altitude
> 4) sets of X,Y,Z points that define the boundary

d. Ellipse

> 1) center's latitude
> 2) center's longitude
> 3) center's altitude
> 4) semi-major axis
> 5) semi-minor axis
> 6) inclination from north

— Confidence level of information (i.e., percent likelihood that caller is within geometric figure).

— Motion information

a. Velocity

b. Azimuth

c. Declination

d. Confidence level

It should be noted that complexities surrounding the merging of location solutions and wireless systems is evolutionary with minimum requirements changing over time. The above format allows for the evolution of such requirements.

Annex C - Location Systems and Technologies

This annex is for information purposes only and is not an attempt to endorse any particular technology and is not intended to provide a complete list of location technologies.

Information on the organizations listed in this annex was obtained from:

- Contribution WJEM(911)/94.10.11-011, "Survey of Location Technologies to Support Mobile 9-1-1" that was provided by both APCO and the State of California

- other JEM contributions

- presentations made by JEM participants

C.1 Network-Centric Location Systems

The following network-centric location systems perform a location function within the network infrastructure:

- Associated Communications Corporation

- Cartesia Corporation

- Engineering Research Associates (ERA)

- KSI Inc.

- Lattice Corporation

- Lockheed Sanders, Inc.

- TrackMobile, Inc.

- U.S. West New Vector Group

- U.S. West Technologies, Inc.

C.2 Mobile-Centric Location Systems

The following mobile-centric systems perform locations within or as an adjunct to the mobile station.

- Galaxy Microsystems, Inc.

- Smith Advanced Technology, Inc.

- Terrapin Corporation

C.3 Network-Centric Location Technologies

The following Network-centric location technologies perform a location function within the network infrastructure:

- ArrayComm, Inc.
- ESL, Inc.
- OAR Corporation
- Scientific Research Laboratories, Inc.
- Qualcomm, Inc.

C.4 Systems Based on External Location Network

The following systems are based on external location networks that require infrastructure separate from that which is necessary for wireless communications.

- Automatic Vehicle Monitoring
- NAVSYS Corporation